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CRANES AND AGRICULTURE: A DELICATE BALANCE

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Abstract: Cranes around the world are closely affiliated with wetland and grassland ecosystems. Loss and degradation of those wetland and grassland habitats, primarily from agricultural activities, pose the greatest threats to all crane species, and indeed to many associated wetland and grassland birds. Some crane species have adapted to traditional farming practices, and many have benefitted from agricultural crops. As human populations and agricultural demands have expanded and intensified, however, conflicts between cranes and farmers are becoming more severe. We describe the development and content of a new guide and its value for researchers and conservationists in North America and for connecting with others dealing with these issues around the world. "Cranes and Agriculture: a Global Guide for Sharing the Landscape" gathers published information and personal accounts and experiences around the nexus between cranes and agriculture. The document outlines the life history and feeding ecology of cranes as they relate to both natural habitats and agricultural lands; explores the patterns of agricultural development and change over the last 100 years and explains how crane populations have responded; examines the interaction between cranes and domestic animals; explains the various threats that the crane-agriculture interface poses to cranes; reviews available methodologies to mitigate human-wildlife conflicts that arise as a result of this interface; discusses considerations that arise from a farmer's perspective, with examples; and provides ideas for developing programs and partnerships that either mitigate for the conflicts that can arise, or make use of the opportunity provided by the crane-agriculture interface.

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Key words: agriculture, cranes, crops, grasslands, human-wildlife conflicts, mitigate, wetlands.

NOCTURNAL ROOSTING BEHAVIOR OF SANDHILL CRANES ON THE PLATTE RIVER, NEBRASKA

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Abstract: The Central Platte River Valley (CPRV) in south-central Nebraska attracts over half a million sandhill cranes (*Grus canadensis*) each spring, and comprises the principal spring staging area for the Mid-Continent Population. At night, the cranes roost in the braided channel of the river, preferring to stand in shallow, slow-moving water, far from potential sources of disturbance. Springtime water flows in the Central Platte River were drastically reduced during the last century as a result of upstream dams and diversions that supply water for irrigation and hydropower production. Limited water flows and the encroachment of woody vegetation have greatly reduced the availability of suitable roosting habitat. This has prompted management concerns (e.g., from the U.S. Fish and Wildlife Service and The Crane Trust) about possible adverse consequences for the Mid-Continent Population of sandhill cranes and populations of several endangered or threatened water birds, including whooping cranes (*G. americana*), that use the CPRV during their annual cycle. Whereas cranes normally exhibit minimal movement throughout the night, rapid changes in water depth due to hydrocycling or limited availability of suitable roosting habitat may force cranes to increase their nocturnal activity. Nocturnal roosts were monitored using thermal imagers and night vision equipment during spring staging 2007-2009. We analyzed time budget data for 7,224 focal-birds collected at 58 observation points, scan sample data from 30 observation points, and disturbances from 63 observation points. We assessed restless behavior and nocturnal crane disturbance rates in relation to size of roost, time of night, river flow metrics, channel width, and landscape variables, and quantified causes of disturbance.

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Key words: CPRV, *Grus canadensis*, Mid-Continent Population, nocturnal disturbance, Platte River, roost, sandhill crane, spring.

USING HOME RANGES AND SITE FIDELITY TO IDENTIFY AREAS OF IMPORTANCE FOR OVERWINTERING SANDHILL CRANES ON THE SOUTHERN HIGH PLAINS

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Abstract: Approximately 82% of the Mid-Continent Population of sandhill cranes (*Grus canadensis*) overwinter on the Southern High Plains (SHP) of Texas and New Mexico. We identified wintering areas of importance, estimated home ranges, and assessed site fidelity of sandhill cranes to wintering sites in the SHP, 2014-2016. We captured and equipped a platform transmitter terminal to 17 and 10 cranes during winters 2014-15 and 2015-16, respectively. We used winter locations (from capture to exit from winter range or within approximately 32-36°N and 100-104°W in subsequent winters) to estimate home ranges (95% contours) using the Brownian Bridge Movement Model in Program R. Of the 17 cranes captured in winter 2014-15, 88% ($n = 15$) returned to overwinter in the SHP the following year. We identified several areas of importance, each containing ≥ 1 saline lake or playa wetland used by >1 crane for $>50\%$ of a complete winter. Saline lakes remain an important component to sandhill crane ecology on the SHP, and the large-scale loss of saline lakes due to land use practices over the past 50 years are disconcerting. This study is part of a larger, ongoing assessment of the sustainability of the SHP landscape for this growing population. These spatial parameters, along with population parameters, landscape composition, and climate parameters, will be used to inform models to estimate future population and spatial demographics under several land cover and climate scenarios.

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Key words: *Grus canadensis*, home range, Mid-Continent Population, sandhill crane, site fidelity, Southern High Plains, Texas, winter.

IN VITRO METHODS FOR EXAMINING MALE FERTILITY IN CRANE SPECIES

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Abstract: On average, fertility of captive-laid whooping crane (*Grus americana*) eggs is much lower than observed in the wild. To date, the underlying cause of low egg fertility in captive birds is unknown. The overall goal of the present study was to establish an *in vitro* assay to examine fertility of individual males. Our specific objectives included: 1) establish a method to chemically induce acrosome reaction and 2) assess the ability of crane sperm to interact with the inner perivitelline layer (IPVL; the functional site of fertilization) of domestic chickens. In objective 1, 3 fresh semen samples from different males were pooled and incubated in Minimum Essential Media (MEM) containing either 5 or 10 mmol calcium chloride (CaCl₂) with and without calcium ionophore (Ca²⁺) for 20 minutes or 1 hour. Successful acrosome reaction was determined if the subacrosomal rod was visible using coomassie blue stain with light microscopy. Incubating sperm in 10 mmol CaCl₂ resulted in the most sperm with a reacted acrosome at both time points (MEM-5%, 34%; 5 mmol-16%, 55% ; 5 mmol+Ca²⁺-20%, 52%; 10 mmol-23%, 57%; 10 mmol+Ca²⁺-16%, 53%). In objective 2, semen samples were incubated with chicken IPVL in MEM with 10 mmol CaCl₂ for 1 hour and assessed for penetrations/holes under dark field microscopy. Preliminary findings demonstrate that crane sperm were able to interact with chicken perivitelline layers as multiple holes were observed after incubation. In summary, we have established an *in vitro* assay for assessing sperm function which is an important step toward understanding low egg fertility in captive whooping cranes.

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Key words: acrosome reaction, captive, fertility, *Grus americana*, sperm, whooping crane.

CAPTIVE ENVIRONMENT ENHANCES REPRODUCTIVE PERFORMANCE IN CAPTIVE WHOOPING CRANE PAIRS

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Abstract: Whooping cranes (*Grus americana*) naturally breed in wetland habitats. However, captive cranes at Patuxent Wildlife Research Center are housed in dry outdoor pens, which we believe may compromise reproduction. We hypothesized housing crane pairs in an enclosure that mimics their natural environment would enhance reproduction. In the present study, 8 crane pairs were housed in traditional dry pens in Year 1, and then moved to either new dry pens (control, $n = 4$) or ponded pens (wetland, $n = 4$) for Years 2 and 3. Fecal estrogen metabolites and numbers of eggs laid were assessed compared among groups and years using linear mixed effect models with individual serving as the random effect. There was no significant difference in estrogen metabolites among females of each group in Year 1. When compared within each enclosure group, there was no difference in estrogen metabolite concentration among study years in the control females. However, we observed an increase in estrogen production excreted by wetland females in each consecutive year after being moved to the new pen, with Year 3 being significantly higher than Year 1 (Year 1: 286.06; Year 2: 345.62; Year 3: 477.63, $P < 0.001$). The number of eggs laid increased in 2 of the 4 pairs housed in the wetland pens, while control pairs continued to produce eggs at similar low levels. These findings demonstrate the beneficial effects of natural environment on reproductive performance of captive whooping cranes.

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Key words: captive, estrogen, *Grus americana*, natural environment, reproductive performance, wetland pens, whooping crane.

EVIDENCE OF NEW SUMMER AREAS AND MIXING OF TWO GREATER SANDHILL CRANE POPULATIONS IN THE INTERMOUNTAIN WEST

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Abstract: Population delineation throughout the annual life cycle is needed to formulate regional and national management and conservation strategies for migratory birds such as sandhill cranes (*Grus canadensis*). Our objectives were to use global positioning system satellite transmitter terminals to determine if intermingling occurs among any of the western greater sandhill crane populations (*G. c. tabida*) (Rocky Mountain Population, Lower Colorado River Valley Population, and Central Valley Population) and identify new summering areas. Capture and marking occurred during winter and summer months on private lands in California and Idaho, National Wildlife Refuges (NWRs: Bosque del Apache, Cibola, and Sonny Bono Salton Sea) and state-owned areas (Ladd Marsh Wildlife Management Area). A majority of marked greater sandhill cranes summered in what are already established population breeding ranges. A small number of greater sandhill cranes summered outside of traditional breeding areas in west-central Idaho around Cascade Reservoir near Donnelly and Cascade, Idaho. A greater sandhill crane colt captured near Donnelly, Idaho, in July 2014 survived to winter migration and moved south to areas associated with the Rocky Mountain Population, and a marked CVP crane from Ladd Marsh staged in the Payette River Valley in fall 2016 while marked LCRV birds were also in the river valley. The integration of the western greater sandhill crane populations provides evidence of potential intermingling between western crane populations. We suggest that continued marking and banding efforts of all 3 western populations of greater sandhill cranes will accurately delineate population boundaries and connectivity and inform management decisions for the 3 populations.

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Key words: CVP, greater sandhill crane, *Grus canadensis tabida*, LCRVP, population boundaries, RMP, western populations.

INCIDENTS OF WHOOPING CRANE SHOOTINGS AND THEIR EFFECT ON RECOVERY EFFORTS

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Abstract: Whooping crane shootings since 1967 contributed to the historic decline of whooping cranes (*Grus americana*), and they continue to affect all remnant and reintroduced populations today. Here we examined the 27 confirmed shooting cases that have occurred since the whooping crane was listed as a Federally Endangered Species in 1967. In the past decade there has been a concerning increase in the number of shootings, especially in the reintroduced populations. In the period from 1967 to 1999, there were 5 documented shooting cases; in the period between 2000 and 2016, there were 22 documented shooting cases. Since 2000, 72% of the confirmed shooting cases have taken place in the reintroduced populations; shootings account for 19% of known mortality in the Eastern Migratory Population and 24% in the Louisiana Non-migratory Population. Most shooting cases are unrelated to a hunting season, although more than half of the cases in the Aransas Wood Buffalo Population have been related to hunting. In 60% of the cases, a perpetrator was identified, and in 48% of the cases a perpetrator was punished for the crime. Cases have rarely been tried under the Endangered Species Act, but rather the Migratory Bird Treaty Act and state laws have been used. The severity of punishment for shooting a whooping crane has varied widely. To reduce the rate of whooping crane shootings, we recommend public awareness campaigns designed to raise pride in whooping cranes, in conjunction with advocacy to officials in the criminal justice system to increase penalties.

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Key words: *Grus americana*, mortality, public awareness, shootings, whooping crane.

IDENTIFYING MIGRATION CONNECTIVITY AND FOCUS AREAS FOR MANAGEMENT OF THE LOWER COLORADO RIVER VALLEY POPULATION OF GREATER SANDHILL CRANES

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Abstract: The Lower Colorado River Valley Population (LCRVP) of greater sandhill cranes (*Grus canadensis tabida*) is the smallest of the migratory sandhill crane populations in North America and has been the least researched of the 3 greater sandhill crane populations in the western United States. During 2014 we equipped 17 greater sandhill cranes on 2 winter study sites in Arizona and California and on a breeding area in Idaho with ARGOS satellite platform transmitter terminals to track movements. We used locations to identify and rank migratory staging and stopovers, referred to as areas of migratory importance (AMIs), that were used by the LCRVP during 5 migrations (spring 2014-spring 2016). We identified 21 AMIs, with the most used areas being Wayne E. Kirch Wildlife Management Area, Pahrnagat National Wildlife Refuge, and surrounding areas in Nevada. Five AMIs were also summer termini for sandhill cranes, including Ruby Lake NWR, Lund, Humboldt River, Bear River, and Duck Valley Indian Reservation, based on summer location data. AMIs in the Lake Mead area were used moderately, but may need to be focused on as a whole unit versus individual AMIs for management purposes. As a population relying on an arid region that is continuously developing and gradually morphing into a hub for alternative energy, prioritizing and conserving AMIs is warranted for LCRVP management. With intermixing occurring between the 3 western greater sandhill crane populations, the implications of prioritizing and conserving AMIs at the management level have the potential to positively impact more than the LCRVP.

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Key words: AMI, areas of migratory importance, greater sandhill crane, *Grus canadensis tabida*, LCRVP, Lower Colorado River Valley Population, western populations.

WINTER SPACE USE OF THE LOWER COLORADO RIVER VALLEY POPULATION OF GREATER SANDHILL CRANES

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Abstract: The Lower Colorado River Valley Population (LCRVP) of greater sandhill cranes (*Grus canadensis tabida*) is the least abundant and has been 1 of the least researched of the migratory sandhill crane populations in North America. Population surveys and literature review suggest that additional information regarding baseline wintering ecology, including information pertaining to spatial ecology, is warranted for management decisions. We attached ARGOS satellite platform transmitter terminals to 17 greater sandhill cranes on 3 study sites in southwestern Arizona, southeastern California, and west-central Idaho during 2014 to assess winter space use of the LCRVP. We assessed mean winter home range and core area size, fidelity, and overlap among tagged individuals using Brownian bridge movement models (BBMM). Mean winter home range size was 18,711 ha (SE = 3,809 ha). Mean core area estimate was 3,237 ha (SE = 599 ha). Ten individuals showed relatively strong home range fidelity over the 2 years, with >85% overlap with their home range from the previous year. Two individuals displayed no home range fidelity by wintering at a different wintering area during the 2014-15 winter than they did during winter 2013-14. All home ranges partially overlapped and 6 individuals overlapped 100% with at least 1 home range from another individual. The home ranges reported herein were considerably larger than home range estimates in similar sandhill crane studies, indicating necessary resources (roost sites, foraging areas) on wintering grounds are not arranged spatially in a way that minimizes overwinter home range size and movements.

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Key words: greater sandhill crane, *Grus canadensis tabida*, home range fidelity, LCRVP, Lower Colorado River Valley Population, PTT, winter home range.

ENVIRONMENTAL SPATIAL DATA LAYER DEVELOPMENT FOR WINTERING WHOOPING CRANE SPECIES DISTRIBUTION MODEL

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Abstract: Species distribution models are influenced by the quality of species occurrence data and environmental spatial data layer input. In this paper we developed improved environmental spatial data layers to model the distribution of wintering whooping cranes along the Texas coast. We reviewed the accuracy of the Composite Habitat Type Data set (CHTD) recently used to estimate habitat suitability for wintering whooping cranes and modified the data based on inconsistencies observed. The final land cover data layer was reclassified to 16 mesohabitat types potentially influencing the distribution of wintering whooping cranes. Additionally, we created a unique soil data layer from freely available Natural Resource Conservation Service SSURGO database based on 3 characteristics: hydric, inundation, and salinity. Additional environmental data layers created included slope and roughness from digital elevation models data; water salinity from Texas Water Development Board TxBlend models; and minimum, maximum, and mean precipitation from local weather station data. These data along with whooping crane presence-only data and other landscape data were used as inputs in Maxent software to estimate the probability of whooping crane habitat use within our study area along the Texas coast and highlight key areas for current and future conservation efforts. Our preliminary approach for developing improved environmental spatial data to better estimate wintering whooping crane distribution provides initial framework for whooping crane modeling on the Texas coast that could be continuously updated with improved spatial and species occurrence data as it become available in the future.

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Key words: environmental data layer, *Grus americana*, habitat use, species distribution model, Texas, whooping crane, wintering.

DOES HEALTH ON NATAL GROUNDS DRIVE MIGRATORY BEHAVIORS OF JUVENILE WHOOPING CRANES?

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Abstract: Effective conservation of whooping cranes (*Grus americana*) must consider how events on natal grounds carry over to influence performance in subsequent periods. Migration is energetically demanding, so the health of cranes prior to the onset of migration should play an important role in determining their subsequent movements, habitat use, and stopover decisions. We tested this hypothesis by correlating individual health assessments (energy management, disease status, body mass) at banding with subsequent migratory schedule and movement data derived from satellite tracking of 18 juveniles originating in Wood Buffalo National Park, Canada. Measures of energy management, assessed using the hormone corticosterone from natal feathers collected 40-60 days post-hatch, were higher in males than females. Of the 5 viral pathogens we considered, antibodies against infectious bursal disease virus were detected in all individuals we tested, and antibodies against West Nile virus were present in only 3 birds. Of the 3 microbiological pathogens we considered, only *Escherichia coli* was observed in cultures of cloacal swabs, and it was present in all individuals. Small sample sizes reduced statistical power, but preliminary results suggest that previous exposure to potential pathogens did not appear to impact health or subsequent migration behaviors. Although our measure of energy management during the period of feather growth may have been too temporally removed from migration to adequately reflect pre-migratory condition, our data provide a baseline measure that can be used as a future monitoring tool.

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Key words: *Grus americana*, health, migration, migratory behavior, whooping crane, Wood Buffalo National Park.

IMPLICATIONS OF GLOBAL WETLAND MANAGEMENT FOR CRANE CONSERVATION

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Abstract: Due to high levels of wetland degradation and loss, large proportions of crane and other wetland bird populations live in managed wetlands. In the state of New York, managed wetlands have demonstrated 2.4 times greater abundance of waterfowl than non-managed wetlands. However, managed wetlands have been critiqued as less than optimal habitat for wetland birds, which begs the question, "How does wetland management affect wetland bird communities?" Several studies note that changes in water levels can drastically affect the reproductive success of wetland birds. This poster reviews literature on global wetland management techniques, procedures, and policies with an emphasis on water level management and the implications on wetland bird communities. This information could play an important role in crane conservation.

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Key words: crane conservation, New York, water level management, wetland bird communities.

SUMMER HOME RANGE AND HABITAT USE OF WHOOPING CRANES IN THE EASTERN MIGRATORY POPULATION

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Abstract: When the Eastern Migratory Population (EMP) of whooping cranes (*Grus americana*) was established in Wisconsin in 2001, it was not entirely known how these birds would utilize this landscape after the dramatic changes that have occurred since the species was extirpated from the Midwest over 100 years ago. To understand how the population is using this altered landscape, baseline summer (April-September) home range and habitat use data (2011-2014) of territorial and non-territorial whooping cranes were analyzed. VHF transmitters were used to track movements of territorial adults from dawn roost to evening roost while locations of non-territorial individuals were acquired through satellite transmitters. Home range of 8 territorial cranes averaged 4.58 km² (SE = 4.31, range 0.78-16.64). Home range of 9 non-territorial individuals averaged 7,750 km² (SE = 5,564) in their second year, 3,490 km² (SE = 5,159, $n = 7$) in their third year, and 415 km² (SE = 415, $n = 4$) in their fourth year. Territory composition of breeding adults consisted of 57% wetland habitat, while cranes were located in wetland habitat 75% of the time. Non-territorial adults used upland (51.0%) and wetland (49.4%) areas in equal proportion throughout the summer months. As this reintroduced population expands into other breeding areas in Wisconsin, it will be important to understand how the different landscapes throughout central and eastern parts of the state affect whooping crane habitat use.

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Key words: Eastern Migratory Population, *Grus americana*, habitat use, home range, summer, Wisconsin, whooping crane.

SIGHTS AND SOUNDS OF THE SPRING SANDHILL CRANE MIGRATION ON THE PLATTE RIVER

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Abstract: The importance of the Platte River in south-central Nebraska for providing key stopover habitat for sandhill cranes has been well documented through research activities, photography, and written works that have spanned several decades, and awareness has spread around the world about the spectacle of hundreds of thousands of cranes converging along the river over a period of a few weeks each spring. Increasingly, advances in visual and audio technologies are allowing us to perceive this migration event in new ways, as well as to share aspects of it with broader audiences. We are combining time-lapse photography and sound recordings to capture visual and acoustic diversity on the Central Platte during spring migration through a collaboration among the Platte Basin Timelapse Project (www.plattebasintimelapse.com), Purdue University's Center for Global Soundscapes (www.centerforglobalsoundscapes.org), and conservation partners in Nebraska. Here we present examples of time-lapse photography and acoustic recordings captured along the Platte River during 2 spring migrations and share ways that these types of information may inform research, education, and public outreach and communication.

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Key words: acoustic recordings, *Grus canadensis*, Nebraska, Platte River, public outreach, sandhill crane, spring migration, time-lapse photography.

ARE THERE EMERGING HEALTH CONCERNS FOR EASTERN MIGRATORY WHOOPING CRANES?

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Abstract: We reviewed detailed necropsy data from the Eastern Migratory Population (EMP) of whooping cranes (*Grus americana*) to identify causes of death and assess the ongoing health management of the reintroduction effort. Previous published reviews were based on limited samples from fewer mortalities or incomplete review of available laboratory and pathology findings. We reviewed records from 121 mortalities of captive-reared, reintroduced EMP cranes with postmortem results that were logged between 2001 and mid-November 2016. The cause of death was undetermined from nearly half ($n = 59$) of these cases due to carcass decomposition and/or postmortem scavenging. Causes of death in the remaining 62 cases included predation (42%, $n = 26$), trauma (24%, $n = 15$), gunshot (18%, $n = 11$), infectious disease (10%, $n = 6$), musculoskeletal problem (3%, $n = 2$), reproductive problem (1.5%, $n = 1$), and iatrogenic/management-related (1.5%, $n = 1$). We also reviewed records from 12 mortalities of wild-hatched EMP cranes with postmortem results. The cause of death was undetermined from 4 of these cases. Causes of death in the remaining 8 cases included infectious disease ($n = 4$), predation ($n = 3$), and trauma ($n = 1$). Notable emerging concerns from this review included high rates of gunshot deaths among captive-reared and reintroduced whooping cranes along with a high proportion of infectious disease-related cases in both captive-reared and wild-hatched segments of the population. Infectious disease cases involved multiple infectious pathogens; several of these pathogens are previously unrecognized health threats to cranes of the EMP. Postmortem studies such as this are essential to understanding the success of endangered species reintroduction programs and to better focus conservation efforts. Further research is necessary to understand how these findings compare to known health threats from each of the captive, Aransas-Wood Buffalo, and reintroduced Florida Non-migratory Populations.

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Key words: disease, Eastern Migratory Population, EMP, *Grus americana*, gunshot, health, mortalities, reintroduction, whooping crane.

EFFECTIVENESS OF PREDATOR REMOVAL FOR ENHANCING A CRANE POPULATION

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Abstract: Predation has been identified as the most common cause of death in the Mississippi sandhill crane (*Grus canadensis pulla*) and is likely an important factor limiting recovery of this endangered non-migratory subspecies. Predator removal has been successful in enhancing some duck populations and was begun for this population in 1985 on the Mississippi Sandhill Crane National Wildlife Refuge in southeast Mississippi. Over 30 years, Refuge personnel, USDA technicians, and local contract trappers used toe-hold, snare, and box traps to trap and remove predators, focusing on providing protection during 2 vulnerable periods—nesting season and the annual release of captive-reared juveniles. We considered coyotes (*Canis latrans*), bobcat (*Lynx rufus*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), and dog to be target species, all documented as taking crane eggs, chicks, juveniles, or adults. During 1985-2006 and 2008-2016, there was an average of 3,647 trap-nights, 29 large mammals removed, and 77.5 target mammals removed per year. There was no correlation between measures of trapping effort or number of predators removed in a year with known number of cranes predated, number of chicks fledged, or first-year post-release survival. During the 4-year period 2013-2016 using 1 local contractor, the average number fledged per year was 6.0, nearly twice the rate of any previous period. Using 2 main Refuge units as control and experimental treatment areas may enhance evaluation for predator removal effectiveness.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:157

Key words: *Grus canadensis pulla*, Mississippi sandhill crane, predation, predator removal, Refuge, trapping.

SURVIVAL ANALYSIS OF CAPTIVE-REARED AND RELEASED MISSISSIPPI SANDHILL CRANES

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Abstract: The restocking of endangered Mississippi sandhill cranes (*Grus canadensis pulla*) is the largest and longest release program using captive-reared cranes in the world. Since 1981, captive-reared juveniles have been released annually at the Mississippi Sandhill Crane National Wildlife Refuge to augment the small resident population. The captive crane population was first developed at Patuxent Wildlife Research Center (PWRC) in the 1960s, then moved in the mid-1990s to the Audubon Species Survival Center (ASSC), Louisiana, and the White Oak Conservation Center (WOCC), Florida. Chicks were either costume- or parent-reared and socialized in captivity, then acclimated and released at the refuge. In this study, we evaluate the fate of 520 tagged juvenile Mississippi sandhill cranes by using survival analysis to understand probability of crane survival under a suite of different treatment effects. We evaluated effects including sex, captive source (PWRC, ASSC, WOCC), captive rearing type (costume or parent), cohort type (all costume-reared, all parent-reared, or mixed rearing), location of release site ($n = 13$ locations), pen type, and hatch year. The probability of survival was modeled with a series of candidate survival functions including Weibull, exponential, and log-normal formulations. The competing candidate survival functions were evaluated using Akaike Information Criteria. Model parameters of the preferred candidate models and their associated distributions were estimated using Bayesian parameter estimation methods. We found that rearing type, cohort, and source impacted the probability of survival for the fourth year and that mean annual survival probability has increased from 1979 to 2015 across all treatment levels examined. Quantitative survival analysis of the historical data of Mississippi sandhill cranes will inform the efficacy of alternate techniques and help to optimize management and conservation measures.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:158

Key words: captive-reared, *Grus canadensis pulla*, Mississippi sandhill crane, release program, survival analysis.

HABITAT USE BY SANDHILL CRANES WINTERING IN THE AGRICULTURAL LANDSCAPE OF THE SACRAMENTO-SAN JOAQUIN RIVER DELTA OF CALIFORNIA

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Abstract: The Sacramento-San Joaquin River Delta region of California is an important wintering region for sympatric greater (*Grus canadensis tabida*) and lesser (*G. c. canadensis*) sandhill cranes. Basic information about sandhill crane use of habitats in their winter landscape is needed to design biologically driven conservation strategies. We monitored radio-tagged birds of each subspecies for 2 winters and conducted foraging counts to document their habitat use. With the exception of vineyards and orchards, cranes used the major crops and habitat types that were available in the landscapes surrounding their roost sites, but focused most of their foraging in grain crops. Cranes generally avoided dry corn stubble, selected dry rice stubble early in the season, and rarely used dry wild rice (*Zizania palustris*) stubble. Tilled fields were usually avoided but were occasionally used shortly after tillage. Mulched corn ranked high in comparison to other corn treatments while mulched rice was used similarly to dry rice stubble. Both subspecies often showed high selection of croplands when fields were initially flooded. Cranes were also attracted to new plantings of pasture and winter wheat. One important difference between the subspecies was that lesser sandhill cranes used alfalfa, which was generally avoided by greater sandhill cranes. If wildlife managers want to favor winter field use by foraging cranes, they could provide incentives for favorable practices such as for production of grain crops, to reduce or delay tillage and flooding of grain fields, to periodically irrigate pasture and grain stubble crop types, and to increase the practice of mulching of corn stubble.

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Key words: agricultural landscape, California, grain crops, *Grus canadensis*, habitat use, Sacramento-San Joaquin River Delta, sandhill cranes, wintering.

NON-INVASIVE GENETICS OF SANDHILL CRANES IN ONTARIO

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Abstract: Eastern Population (EP) sandhill cranes (*Grus canadensis*) are 1 of the few conservation success stories. EP sandhill cranes have recovered from a severe bottleneck and expanded their range across the Great Lakes and beyond. As EP sandhill cranes continue to flourish, it becomes even more important to create accurate population models to predict continued growth and the effect of population stressors, such as the reintroduction of hunting. Traditionally, population surveys are conducted during the fall migration on staging grounds. We often consider EP sandhill cranes as a single closed population when conducting surveys, yet there is evidence to the contrary, such as assisted recolonization from the Mid-Continent Population. Genetic sampling can be used to determine whether sub-populations are present, but typically require the animal to be captured to collect blood or tissue samples. Non-invasive genetic sampling allows us to collect samples from a population with minimal impact and reduced cost. This study uses shed feathers collected on fall staging grounds in Ontario as a DNA source. The feather samples will be compared to known origin samples from the Eastern and Mid-Continent Populations. We will use Bayesian clustering to determine the number of subpopulation groups present on fall staging grounds. The results from this study can be used to build a more accurate population model and determine whether we should consider the population open during fall surveys. This will allow us to predict changes in the population before they occur and prevent another decline of the population.

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Key words: Eastern Population, EP, genetic sampling, *Grus canadensis*, Ontario, sandhill crane.

A MAJOR NEW SPRING STAGING AREA FOR THE MID-CONTINENT POPULATION OF SANDHILL CRANES IN SOUTH DAKOTA: PROBABLE CAUSES, CHARACTERISTICS, AND CONSERVATION PLANS

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Abstract: The Central Platte River Valley (CPRV) of south-central Nebraska became a magnet to the Mid-Continent (MCP) of sandhill cranes (*Grus canadensis*) starting in the early 1940s following a dramatic increase in corn residues from the introduction of the mechanical corn picker. An abundance of corn residues allowed cranes during their stay to acquire large fat reserves for migration and reproduction. With the development of more efficient harvesting techniques in recent decades and intense competition from other wildlife, greater sandhill cranes store less fat in the CPRV than in the past. With a warming climate and corn residues becoming scarce by late March, greater sandhill cranes (*G. c. tabida*) are departing earlier from the CPRV than in the past and are moving a relatively short distance to eastern South Dakota where most now stage in the James River Valley and the U.S. Highway 281 corridor from Mitchell to Redfield. All 20 GPS-monitored cranes captured and marked along the Texas Gulf Coast during the 2015-16 winter stopped in eastern South Dakota during spring 2016. We assessed numbers of greater sandhill cranes stopping in eastern South Dakota in spring, and will discuss chronology of use, habitat use, and movements during their stay. We also compared length and pattern of stay during 2016 with PTT-tagged cranes during 1998-2004. Last, we will discuss the current status of efforts to protect native grassland tracts that contain shallow wetland roost sites vital to the continued use of this staging area from conversion to corn and soybean agriculture.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:159

Key words: Central Platte River Valley, corn residues, CPRV, *Grus canadensis*, Mid-Continent Population, MCP, Nebraska, sandhill crane, South Dakota, spring staging area.

SUMMER RESOURCE SELECTION OF THE LOWER COLORADO RIVER VALLEY POPULATION OF GREATER SANDHILL CRANES

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Abstract: Much of the Intermountain West is publicly owned and managed by the U.S. Forest Service and Bureau of Land Management (~80%). The majority of wetland resources, however, occur on privately owned lands. In order to influence and direct conservation efforts (i.e., easements and acquisition), resource selection of an iconic western migratory bird such as the greater sandhill crane (*Grus canadensis tabida*) can be used to identify the most important areas of concern. On the summering grounds, preferred nesting habitats throughout the breeding range are under increasing pressure due to water management and agricultural practices which contribute to the desiccation of meadows used by cranes for nesting. Our objective was to use resource selection analysis to identify which habitats are most important to summering greater sandhill cranes. During 2014-2016, 13 PTT-tagged sandhill cranes from the Lower Colorado River Valley Population (LCRVP) summered in Nevada and Idaho, and 48.8% (1,725 of 3,532) of the GPS locations were in a grassland, shrub, scrub, or meadow habitat category. The standardized selection ratio suggested cranes disproportionately selected wetlands and open water compared to their availability during diurnal and roosting periods at the population landscape level for both overall locations (diurnal: $B_i = 0.68$, roost: $B_i = 0.77$) and by individuals (diurnal: $B_i = 0.68$, roost: $B_i = 0.76$). The standardized selection ratio for individual locations by individual home range still showed selection for wetlands and open water but lower in factor (diurnal: $B_i = 0.35$, roost: $B_i = 0.46$). Our results indicate conserving remaining wetland resources is critical in order to maintain the population of LCRVP cranes.

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Key words: greater sandhill crane, *Grus canadensis tabida*, Idaho, Lower Colorado River Valley Population, LCRVP, Nevada, standardized habitat selection ratio.

ASSESSMENT OF THE IMPACT TO CRANES FROM A PLANNED TRANSMISSION LINE

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Abstract: A section of the Badger-Coulee 345Kv transmission line has been approved by the Public Service Commission of Wisconsin to follow the Wisconsin River corridor between Wisconsin Dells and Portage, Wisconsin. This section of the Wisconsin River offers many sandbars which serve as ideal roosting habitat for resident and migrating cranes. While resident adult cranes might be familiar with the area, juvenile cranes preparing for their first migration and non-resident birds gathering in this area to prepare for migration from surrounding counties are especially at risk for collision when the line is completed. More information is needed to quantify how the birds use this area during this critical time. We have quantified the level of crane use in this area to promote planning to assist in determining optimal tower configuration and line height, as well as marking options to deter birds from the lines. A high crane use section of the corridor was split into 5 3.2-km study areas. We recorded crane morning and evening flight paths, numbers of cranes, and flight altitudes. Over 14 weeks, more than 24,000 crane crossings were recorded, at an average height of 81 m above ground level (AGL). We now have an assessment of potential threat to cranes from the line, based on population structure and flight corridors and altitudes. Transmission line development will continue in this region and other areas important to cranes; the development process will be optimized the more that we understand how to prevent negative interactions and mitigate the effect of power lines on bird populations.

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Key words: collision risk, cranes, flight paths, migration, power lines, transmission line, Wisconsin River.

PEOPLE'S AWARENESS AND ATTITUDES ABOUT WHOOPING CRANES AT WHEELER NATIONAL WILDLIFE REFUGE, ALABAMA

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Abstract: The whooping crane (*Grus americana*) was nearly extirpated by the mid-20th century due to habitat conversion and unregulated hunting. As part of the species recovery, there have been attempts to re-establish populations across the United States. Several reintroduced whooping cranes of the Eastern Migratory Population utilize habitat at Wheeler National Wildlife Refuge in northern Alabama during migration and winter. There have also been documented shooting incidents in the region. The combination of a proportionally large and likely growing crane population in northern Alabama and the potential for future human-crane conflicts highlights the need for social science approaches. Using the cognitive hierarchy, a survey was developed to understand the human dimensions of whooping crane conservation in north Alabama. The survey was administered to a sample of 1,500 individuals within a 3-county region where the refuge is located. We then administered a similar survey to birders and waterfowl hunters in Alabama to compare the local population to these specialized groups. Results from all surveys demonstrate low awareness and knowledge of whooping cranes in Alabama. However, respondent attitudes toward crane conservation were generally positive and were best predicted by social norms and emotions. Specialization level of birders was also positively correlated with awareness, knowledge, and pro-conservation behavior. These findings can be used to guide communication and outreach efforts to improve public perception of the species.

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Key words: Alabama, Eastern Migratory Population, *Grus americana*, outreach, public perception, Wheeler National Wildlife Refuge, whooping crane.

AN INDIVIDUAL-BASED EVOLUTIONARY SIMULATION MODEL FOR PREDICTING WHOOPING CRANE REPRODUCTIVE SUCCESS UNDER DIFFERENT CONDITIONS

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Abstract: One of the approaches developed to increase nest success in wild whooping cranes (*Grus americana*) at Necedah National Wildlife Refuge, Wisconsin, is the removal of eggs laid early in the season, which then forces a pair of birds to re-lay later in the season. This technique was developed to shift egg laying such that it did not coincide with the emergence of black flies (*Simulium* spp). Data from the past few years suggest that forced re-nesting has increased nest success but the question remains: Will the birds ever shift to late nesting on their own or will intervention be necessary in perpetuity to maintain higher levels of nest success? To address this question, we built an individual-based evolutionary simulation model that allows managers to predict population persistence based on a variety of modifiable parameters. The model simulates the pairing and nesting of individual birds that have certain properties such as wild- or captive-hatched, age, and nesting preference. Use of the model and various scenarios are presented.

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Key words: *Grus americana*, forced re-nesting, Necedah National Wildlife Refuge, nest success, simulation model, whooping cranes.

GEODATABASE AND SPATIAL TOOL DESIGNS TO PROMOTE RAPID ORGANIZATION AND ANALYSIS OF DATA COLLECTED FROM SANDHILL CRANE PLATFORM TRANSMITTER TERMINALS

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Abstract: Modern advancements in wildlife tracking technologies have led to a substantial increase in both the volume and complexity of spatial ecology datasets. There are significant advantages to using relational database management systems (e.g., Microsoft Access, Oracle, SQL Server) to store and manage these types of data. However, because of the learning curve, time investment, and, in some cases, programming knowledge needed to operate or develop database platforms, most wildlife professionals continue to use spreadsheet programs like Microsoft Excel for spatial data management. We developed a series of shareable and customizable tools to: 1) help wildlife researchers more effectively use Excel spreadsheets for sandhill crane (*Grus canadensis*) data management, 2) automate data management processes that must be repeated each time new ARGOS platform transmitter terminal (PTT) data are downloaded, and 3) mechanize specific Excel-to-R and Excel-to-ArcMap interface procedures to facilitate rapid data analysis. Herein, we present a summary of these toolsets, discuss the design and development of our ArcGIS sandhill crane geodatabase, and present custom ArcGIS geoprocessing sequences developed to reduce the workload of updating map layers in the absence of dynamic Excel-to-ArcGIS links. Our customized macros, tools, and workflows can easily be adapted and customized for similar research on other cranes or other wildlife species. Moreover, they can save wildlife professionals significant amounts of time by improving the efficacy of data management techniques.

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Key words: ArcGIS, database management, Excel, geodatabase, *Grus canadensis*, platform transmitter terminals, sandhill crane, spatial tools.

OBSERVATIONS OF WHOOPING CRANE CHICK AND PARENT-FEEDING INTERACTIONS

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Abstract: Whooping cranes (*Grus americana*) have been the subject of several reintroduction programs. The reintroduction program for the Florida Non-migratory Population first used captive parent-reared whooping crane colts for release. Building on these early results, recent efforts have used the parent-rearing technique to introduce whooping cranes into the Eastern Migratory Population in Wisconsin. Between 2013 and 2015, 11 whooping crane colts were introduced at Necedah National Wildlife Refuge. In 2016, the introduction of parent-reared whooping crane colts was increased, with 14 captive parent-reared colts produced, and 11 introduced to the wild in November. One goal of the introductions is to find potential allo-parents for the colts. Several behavioral observations are used to measure the degree of allo-parenting observed in the wild. One behavioral observation is feeding of the colt by the allo-parents. Parent feeding of whooping crane chicks in captivity is easily observed using remote cameras but has never been well documented. In 2014 we made multiple observations of parental feeding of chicks, or as we observed, interactions of bill to bill, over a period of 3 months from shortly after hatching to shortly before fledging. We were able to make observations on 5 chicks with parents. During the observation sessions parent bill interactions with chick occurred from no interactions up to 105 per hour. We noted a decreasing amount of bill interactions as the chicks aged and were able to forage and feed more on their own, documented in our behavioral observations of the chicks.

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Key words: allo-parents, Eastern Migratory Population, *Grus americana*, parental feeding, parent-rearing, reintroduction, whooping crane.

RELEASING PARENT-REARED WHOOPING CRANES IN WISCONSIN: A PILOT STUDY 2013-2015

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Abstract: From 2013 through 2015, 11 whooping crane (*Grus americana*) colts were released in mid-September in the territories of whooping crane breeding pairs on Necedah National Wildlife Refuge, Wisconsin. The adult pairs were failed breeders, having failed either to hatch an egg or to fledge a hatched chick. The colts were flown to Necedah from the U.S. Geological Survey Patuxent Wildlife Research Center, where the colts had been reared by captive whooping crane breeding pairs. On arrival, the colts were placed in a communal pen for approximately 24 hours to recover from the flight, during which time they received metal and field-readable leg bands, a conventional VHF transmitter, and a satellite transmitter. Temporary pens were constructed in the territories of failed breeding pairs. Single colts were placed in each temporary pen. Colts were released to the wild at 90-120 days of age, 2-5 days after being placed in temporary pens. The releases were timed to coincide with visits by the territorial pairs. Of 11 colts released, 4 died prior to migration. Of the remaining birds, all migrated south with whooping cranes with the exception of 1 colt that, in 2015, moved to Dubuque, Iowa, where it was using an urban marsh with 2 sandhill cranes (*G. canadensis*). This crane was successfully captured and relocated to a roost area on the Wisconsin River, where it remained until migrating south to Louisiana. Estimated survival to 1 year of age was 0.637 (95% CI: 0.352-0.878); this point estimate is lower than for birds released using other methods, but the sampling variance is substantial. Estimated annual survival of birds >1 year of age was 0.857 (95% CI: 0.541-0.996), which is similar to previously-published survival estimates of birds released using the direct autumn release method. The method described shows promise as a rearing and release method for whooping cranes. One hypothesis for poor breeding performance in reintroduced whooping crane populations is inadequate early learning experiences imparted by costume-rearing. The parent-rearing method is designed to provide a substantially different early learning experience, and thus should allow for empirical testing of this hypothesis in the coming years.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:163

Key words: *Grus americana*, Necedah National Wildlife Refuge, parent-reared, rearing and release, whooping crane, Wisconsin.

REARING AND RELEASE OF PARENT-REARED WHOOPING CRANES IN WISCONSIN, 2016

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Abstract: In late 2015, the U.S. Fish and Wildlife Service directed that the ultralight-led reintroductions of whooping cranes (*Grus americana*) cease and that more natural rearing techniques be used for birds released in the Eastern Migratory Population. Based on the 3-year pilot study of parent-reared releases of whooping crane colts, the Whooping Crane Eastern Partnership was directed to release only parent-reared birds in 2016. Fourteen whooping crane chicks were raised for release (2 at the Calgary Zoo, 3 at the International Crane Foundation (ICF), and 9 at USGS Patuxent Wildlife Research Center (Patuxent)). Because of logistical difficulties, the Calgary Zoo birds were unable to be transported to Wisconsin. One bird from ICF injured its wing and was not releasable by the time of this report (21 Oct 2016). Nine birds from Patuxent and 2 birds from ICF were released in the following counties: Outagamie (1), Green Lake (2), Marquette (2), Adams (3), Juneau (2), and Dane (1) in September and October. Eight of these birds currently survive and are moving about the landscape and with some using appropriate habitat. Potential release sites were evaluated based on a number of criteria with main consideration given to previous nesting/rearing successes of targeted adults. Priority was given to releasing juveniles with pairs that had previous chick rearing experience, followed by pairs that had nesting experience, and finally, single birds. Challenges encountered during this first large-scale release of parent-reared whooping crane colts have included: 1) limited access to lands used by the adult whooping cranes in central Wisconsin, as often only foraging fields were available in which to construct temporary release pens, 2) unwillingness of recently released colts to fly with targeted allo-parents from foraging to roost sites, often 2-6 km apart, 3) lack of failed breeding pairs in the Wisconsin eastern rectangle, designated as the preferred release area by the Whooping Crane International Recovery Team, 4) limited access to failed breeding pairs in Wisconsin outside of Necedah National Wildlife Refuge, 5) mortality of 3 of 11 released colts within a month of release (necropsies pending), and 6) poor vigilant behavior.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:164

Key words: allo-parents, Eastern Migratory Population, *Grus americana*, parent-reared, rearing and release, whooping crane, Wisconsin.

SEASONAL MORTALITY IN ARANSAS-WOOD BUFFALO WHOOPING CRANES

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Abstract: Understanding where, when, and why animals die provides information for prioritizing conservation actions. Timing of mortality for migratory birds has been difficult to determine given their mobility and large annual range. Based on assumptions and some supporting data, past assessments of whooping cranes (*Grus americana*) of the Aransas-Wood Buffalo Population determined that 60-80% of mortality after fledging occurred during migration, 20% during winter, and $\leq 5\%$ during summer. As part of a satellite tracking study, we identified 19 confirmed and suspected mortalities of whooping cranes of various ages. Of these, more mortalities occurred during winter (43%) and summer (41%), compared with migration (16%). Summer mortalities occurred exclusively within Wood Buffalo National Park, and all winter mortalities occurred on the primary wintering grounds along the Texas Gulf Coast. Proximate cause of mortality was not known for the majority of the sample, and predation was the most common cause identified. Our results, based on stronger evidence, provide a different perspective from past assessments of mortality. Specifically, migration may be less risky and summering birds at a greater risk than previously assumed. The level of mortality during winter we found supports the notion that winter mortality increases during periods of drought, which occurred during our study. Conservation or management efforts to reduce mortality may have greater effect when focused during breeding and wintering periods, although feasibility and efficacy of these actions will need to be determined.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:164

Key words: Aransas-Wood Buffalo Population, *Grus americana*, satellite tracking, seasonal mortality, whooping crane.

SEASONAL MOVEMENTS AND MULTISCALE HABITAT SELECTION OF WHOOPING CRANES IN NATURAL AND AGRICULTURAL WETLANDS

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Abstract: Eleven of 15 species of cranes (family Gruidae) are considered vulnerable or endangered, and the increase of agriculture and aquaculture at the expense of natural wetlands and grasslands is a threat to cranes worldwide. Yet, the implications of land use changes are not well understood. Here we studied a reintroduced population of whooping crane (*Grus americana*) in coastal and agricultural wetlands of Louisiana and Texas. The objectives were to compare whooping crane movements across seasons, quantify multiscale habitat selection, and identify seasonal shifts in selection. Fifty-three whooping cranes were tracked with satellite transmitters to estimate seasonal core-use areas (50% home range contours) via Brownian bridge movement models, and to assess habitat selection of fresh marsh, aquaculture, rice, and fallow fields. Relative to other crane species, whooping crane core-use areas ($n = 283$) were extremely large (4.7-438 km²) and movements differed by season. Habitat selection appeared to follow seasonal changes of available shallow water on the landscape. The composition of core-use areas showed whooping cranes used more fresh marsh in spring/summer, but shifted to more rice and aquaculture in fall/winter. Within core-use areas, aquaculture was most strongly selected, particularly in the fall when fresh marsh habitats became unsuitable and when core-use areas were smallest. Overall, the shifting of habitat selection over time is likely to require large areas of heterogeneous habitats for whooping cranes. Similar to other waterbirds, understanding the differences between agricultural and natural wetlands appears to depend on spatio-temporal dynamics of water depth.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:165

Key words: aquaculture, *Grus americana*, habitat selection, Louisiana, reintroduced population, seasonal movements, wetlands, whooping crane.

WHOOPING CRANE PUBLIC AWARENESS IN LOUISIANA

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Abstract: The whooping crane (*Grus americana*), an extremely vulnerable species, was found in south Louisiana until its decline during the early 1900s when little conservation ethic was in existence and conversion of prairie and marshland to agriculture became a trend. The last record of a whooping crane in the natural population in Louisiana dates to 1950 when the sole surviving crane was captured from what is now known as White Lake Wetlands Conservation Area. Absent from the Louisiana landscape for more than 60 years, the Louisiana Department of Wildlife and Fisheries (LDWF) began releasing small groups of juvenile cranes onto the landscape in 2011. As of October 2016, the department has released a total of 75 juvenile cranes into southwest Louisiana, with 33 adult birds and 1 juvenile currently surviving. In fall 2011 a tragic event occurred when 2 juvenile whooping cranes were shot and killed in Jefferson Davis Parish by juvenile delinquents. In response to the shootings, LDWF began a partnership with Chevron in 2012 to launch a multi-faceted public education campaign designed to increase public awareness of the presence of whooping cranes in the state. The purpose and objective of this partnership and the agreement were to increase public awareness of LDWF's effort to repopulate whooping cranes in southwest Louisiana and educate Louisiana teachers and youth about the species through the use of formal and informal education initiatives. The long term goal is for an increased awareness of whooping cranes in southwest Louisiana, resulting in public stewardship and enhanced protection of the species.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:165

Key words: *Grus americana*, LDWF, Louisiana, public awareness, White Lake, whooping crane.

DIFFERENTIAL USE OF FRESHWATER PONDS AS HABITAT FOR WHOOPING CRANES ON THE WINTERING GROUNDS

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Abstract: The Aransas-Wood Buffalo whooping cranes (*Grus americana*) are the last, wild population of this federally endangered species in United States and Canada. While they face multiple challenges throughout their range, maintaining high quality habitats throughout the wintering grounds in coastal Texas are critical to ensure their recovery. Paired whooping cranes maintain defended territories in coastal marshes that provide essential food resources during most years; however, when salinities increase past 18 parts per thousand, cranes require alternate dietary water resources. We monitored 4-7 ponds each winter within the Aransas National Wildlife Refuge from 2012 to 2016 by using remote cameras positioned to document crane presence and use. We also documented salinities in adjacent coastal marsh ponds, creeks, and bays as well as mapped crane-habitat associations each winter. Salinities in the bays were higher than average in all years, except winter 2015-16. Coastal marsh salinities were much higher than bays in all years until winter 2015-2016, when salinities markedly decreased with high freshwater inflows and localized rainfall. Increased crane presence at freshwater ponds was generally related to higher salinities, where cranes were documented regularly. Local rainfall appeared to decrease crane use for short periods. Individual whooping cranes identified by color bands typically used ponds closest to their territories in the coastal marsh. Future conservation planning should include coastal prairie adjacent to coastal marshes that would facilitate either use of existing freshwater ponds or enhancement of ponds in key locations.

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Key words: Aransas National Wildlife Refuge, *Grus americana*, freshwater ponds, salinities, Texas, whooping crane, wintering grounds.

PREDATOR AVOIDANCE BEHAVIORS IN SANDHILL CRANES AND WHOOPING CRANES

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Abstract: Despite more than a decade of efforts to increase survival and recruitment in the Eastern Migratory Population (EMP) of whooping cranes (*Grus americana*), chick mortality remains high. Without better recruitment, the population has a low chance of becoming self-sustaining. Predation is a major contributing factor to chick mortality, which begs the question: Do parents have the behaviors necessary for the family group to detect and evade predators? To address this question, we will present live predator stimuli to wild and captive whooping cranes and sandhill cranes (*G. canadensis*). We will examine the variability of responses to determine if predator avoidance behaviors differ across the 4 groups. Our results will inform on-the-ground management of the EMP.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:166

Key words: chick mortality, *Grus americana*, *Grus canadensis*, predation, predator avoidance behavior, sandhill crane, whooping crane.

LOCAL SCALE HABITAT USE AND DAILY MOVEMENTS OF WINTERING WHOOPING CRANES IN THE EASTERN MIGRATORY POPULATION

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Abstract: The reintroduced Eastern Migratory Population (EMP) of whooping cranes (*Grus americana*) currently consists of ca. 100 individuals that breed in Wisconsin and winter throughout the southeastern United States. A general understanding of winter distribution is known for the EMP, but a thorough assessment of local scale habitat characteristics of the wintering grounds has not been conducted. The objectives of this study were to quantify daily movement and identify local scale habitat characteristics of areas used by wintering whooping cranes in the EMP. During 2015 and 2016, we used radio telemetry to track 20 and 23 groups of whooping cranes respectively, each for 1 full day. We recorded location, behavior, and habitat characteristics of used areas every 30 minutes from before sunrise until after sunset. Daily home range sizes averaged 3.6 km² in 2015 and 4.1 km² in 2016, calculated with 95% kernel density estimates. During both winters, cranes moved an average of 8.4 km in 1 day. We describe used areas by combining remotely-sensed land cover data and observed habitat characteristics. Wintering whooping cranes occupied areas including riverine wetlands, flooded agricultural fields, and coastal marshes and appeared to avoid forested and developed areas. We also investigated if whooping cranes select for protected areas, hydric soils, and remote areas far from major roads. This research will help inform management and protection of the wintering grounds of whooping cranes in the EMP and ultimately contribute to the recovery of this endangered species.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:167

Key words: daily movements, Eastern Migratory Population, *Grus americana*, whooping crane, winter habitat use.

RESEARCH AND MANAGEMENT TO INCREASE WHOOPING CRANE CHICK SURVIVAL ON Necedah National Wildlife Refuge, Wisconsin

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Abstract: The major problem preventing successful establishment of the reintroduced eastern migratory whooping crane (*Grus americana*) population is mortality of unfledged chicks. During 2006-2014, only 7 chicks from 7 broods fledged from 40 confirmed chicks from 30 broods. Of broods with 2 chicks, 1 chick typically disappeared within 2 weeks of hatching. Overall, most mortality occurred before 6 weeks of age. In 2015, I initiated 2 studies to identify causes and develop solutions to this problem. To identify potential predators, I operated 4 camera traps at 14 locations on Necedah National Wildlife Refuge during 11 May-14 August; 105 predators photographed in 371 trap-nights included 78% raccoons (*Procyon lotor*) and 8.6% gray wolves (*Canis lupus*). These species and mink (*Neovison vison*) were active during day as well as night. To approximate conditions on a major refuge pool on which successful fledging had occurred in 2006, I gradually lowered water levels 0.5 m (6.4 cm/week), 17 June-10 August. Each of the 2 families on that pool subsequently fledged a chick, while elsewhere in the population during 2015 only 1 chick fledged from 14 other broods. I recommend the following actions be implemented in whooping crane breeding territories: 1) employ advanced monitoring and surveillance technology to identify exact causes and circumstances of chick mortalities, 2) initiate study of biology of predators and develop methods to control their numbers and movements in whooping crane territories, and 3) manage habitat in breeding territories by water level manipulation and reduction of predator cover to promote chick survival.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:167

Key words: chick mortality, *Grus americana*, habitat management, Necedah National Wildlife Refuge, predators, water level manipulation, whooping crane, Wisconsin.

THE IMPORTANCE OF BLACK FLY MONITORING TO UNDERSTANDING NEST DESERTION BY WHOOPING CRANES IN THE EASTERN MIGRATORY POPULATION

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Abstract: Whooping cranes (*Grus americana*) in the Eastern Migratory Population began nesting in 2005. Through 2010, all first nests of the season failed, usually because of synchronous nest desertion. By 2008, black flies (*Simulium annulus* and *S. johannseni*) were identified as the probable causal agents. Methods for monitoring black flies included observation on birds and at deserted nests (2007-2016), photography of nests (2007-2016), CO₂ trapping (2009-2013), and collection at artificial nests containing taxidermic crane mounts (2013-2016). The latter rapid assessment method was more practical and efficient than other methods and accurately recorded the annual outbreak. Emergence resulted in mass synchronous nest desertions in 2007-2011, 2013-2014, and 2016. Desertion was significantly reduced in 2012 when treatment with *Bti* reduced black fly numbers. Because of low flows in the source river, the usual outbreak did not occur in 2015, nor did mass desertion of nests. In 2016 a limited emergence caused nest desertion, but was followed by atypically low black fly numbers. Black fly emergence was related to degree-days, and therefore varied predictably and by year. The nest desertion problem could be solved by effective black fly control. Alternatively, proposed techniques based on invasive nest manipulation to encourage renesting after waning of the black fly season are problematic, i.e., early egg removal favors black fly attack of renests; late removal shortens time available for renesting. Regardless of attempted management of the problem, annual nest success or failure cannot be correctly interpreted without knowledge of the black fly phenology and abundance in each year.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:168

Key words: black fly monitoring, Eastern Migratory Population, *Grus americana*, nest desertion, *Simulium*, whooping crane.

HABITAT AT WHOOPING CRANE NEST SITES ON NECEDAH NATIONAL WILDLIFE REFUGE, WISCONSIN

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Abstract: During 2015 we measured habitat characteristics of all nest sites of whooping cranes (*Grus americana*) on Necedah National Wildlife Refuge (NWR), Wisconsin, the primary reintroduction site of the Eastern Migratory Population. The 20 first nests of the season and 9 renests were found by radiotracking and visual observations from fixed-wing aircraft and ground vehicle surveys. Nests were examined from the ground 24 April-12 June, 1-14 days after conclusion of incubation. Water depth at the nests ranged from 16.0 to 50.3 cm (mean = 34.8 ± 1.60 [1 SE]); no nests were lost to flooding. Open water ranged from 1 to 95% (mean = 36.9 ± 5.2%) of wetland surface within 20 m of the nest. Nests were located in plant communities dominated by coarse sedges (primarily *Carex utriculata*) (41%) or mixtures of coarse sedges and willow (primarily *Salix petiolaris*) (28%); willow accounted for 20-90% of vegetative cover within the latter type. Dominant plant species at remaining nest sites included *C. oligosperma*, *C. lacustris*, *Glyceria borealis*, *Phalaris arundinacea*, *Typha angustifolia*, and *Scirpus cyperinus*. There were no significant habitat differences between sites of first nests of the season and renests. More than 90% of whooping cranes nesting on Necedah NWR do so in or adjacent to man-made impoundments, therefore, water control is a critical feature of management to provide habitat for these breeding pairs.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:168

Key words: *Carex*, *Grus americana*, Necedah National Wildlife Refuge, nest site habitat, sedges, water management, whooping crane, Wisconsin.

SPRING WANDERING: A DISTINCT BEHAVIOR OF YEARLING WHOOPING CRANES IN THE REINTRODUCED EASTERN MIGRATORY POPULATION

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Abstract: From 2001 to 2010, 132 costume-reared juvenile whooping cranes (*Grus americana*) were released after being led by ultralight aircraft from Necedah NWR in central Wisconsin to the Gulf Coast of Florida on their first autumn migration (UL), and 46 juveniles were reintroduced by direct autumn release (DAR) on Necedah NWR. Released UL cranes began their first spring migration from winter release sites in Florida during 24 March-14 April and with few exceptions migrated appropriately back to central Wisconsin. Typically, these returning yearlings only remained briefly and then moved to various other sites farther south in Wisconsin or occasionally to Minnesota, Iowa, or other areas. These yearlings usually returned to Necedah NWR and other sites within the core reintroduction area by early July. This unique pattern is here termed spring wandering. During 2002-2007, these returning yearlings then typically stayed in the core area for the remainder of the summer. Beginning in 2008, yearlings and some 2-year-olds returned to spring wandering locations to summer: 8 in 2008, 12 in 2009, and 15 in 2010. These numbers include DAR birds, which demonstrated the same behavior. Spring wandering was less frequent in older subadults and typically not observed in adults. With few exceptions, adults established their breeding territories in the core reintroduction area. Details of these unique movement patterns are presented, and possible causes and relevance to whooping crane biology and the eastern migratory whooping crane reintroduction are discussed.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:169

Key words: core reintroduction area, Eastern Migratory Population, *Grus americana*, movement patterns, spring wandering, whooping crane, yearling return.

HABITAT SELECTION BY WINTERING SANDHILL CRANES ALONG THE TEXAS GULF COAST

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Abstract: The Gulf Coast subpopulation of the Mid-Continent Population of sandhill crane (*Grus canadensis*) winters along the Texas coast where considerable land use changes have occurred over the last few decades. In order to understand how continuing landscape changes from expanding energy industries, changing agricultural practices, and urban growth will impact sandhill crane distributions in this region, more information is needed on wintering ecology including habitat requirements. From November 2015 through January 2017, satellite transmitters ($n = 31$ with ± 18 m accuracy) programmed to take 4 locations daily were/will be attached to adult sandhill cranes wintering along the Texas coast. Using locations from the 2015-16 and 2016-17 wintering periods and habitat data layers (National Land Cover, surface water maps, and National Agricultural Statistics Service Cropland Data Layer), we will estimate diurnal habitat use along the Texas coast. We will use resource selection functions to estimate selection of habitat types and specific landscape configurations. For winter 2015-16 our analysis includes 18 adult sandhill cranes encompassing 3,249 diurnal locations. Habitat classes most often used included grassland/shrubland (native grassland, shrubland, and pastures), wetlands (woody and herbaceous), fallow agricultural fields, and grain crops (sorghum and corn). We will incorporate data until 15 December 2017 to determine resource selection along the Texas coast. This information will help inform land management decisions and conservation planning needed to ensure the sustainability of the Gulf Coast subpopulation.

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Key words: *Grus canadensis*, Gulf Coast subpopulation, habitat selection, Mid-Continent Population, sandhill crane, Texas, wintering ecology.

SURVIVAL ESTIMATES AND STATE-TRANSITION PROBABILITIES OF DIFFERENT DEMOGRAPHIC GROUPS OF SANDHILL CRANES

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Abstract: Long-term trends in Midwestern sandhill crane (*Grus canadensis*) populations indicate positive growth despite much yearly variability, and continued monitoring will be required for effective management. This study is being conducted to explore relationships between life-history stage and recruitment in sandhill crane populations, as well as to estimate the size of the study population. Since 1990, the International Crane Foundation has collected long-term re-sightings data on territorial and non-territorial sandhill cranes in southcentral Wisconsin. We used these data in a multi-state model to estimate survival and state-transition probabilities of different demographic groups. Primary sessions were on an annual basis, with observations being recorded during the breeding and chick-rearing seasons. State variables were Territorial and Non-territorial, and classifying birds in either category was based on behaviors observed during re-sightings. Results suggest high annual survival rates (~90%) and low annual rates of territory acquisition or loss (~5%). N-mixture models were used to estimate population size with visual observation data independent of the mark-resight models. With estimates of population trends through time, we calibrated our matrix model to produce more realistic estimates of recruitment. Preliminary results suggest that survival of territorial adults and their continued tenure on territory have appreciable effects on growth rate—hence availability of suitable territories may regulate growth rates. Consequently, management of crane populations in the Midwest may depend on creating habitats that support territory establishment.

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Key words: demography, *Grus canadensis*, recruitment, sandhill crane, southcentral Wisconsin, survival rates, territory.

A COMPARISON OF MOVEMENTS BETWEEN ADULTS AND JUVENILE SANDHILL CRANES DURING SPRING AND SUMMER: EVIDENCE FOR PROSPECTING?

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Abstract: Non-breeding juveniles are an important segment of the population, particularly for species with low annual recruitment and delayed time of first breeding such as sandhill cranes (*Grus canadensis*). Juvenile cranes, here referring to any cranes which are not adults, have been under-represented in most crane population ecology studies because they are difficult to capture and are subjected to high mortality rates during their first year. We compared movement characteristics of adult and hatch-year cranes from breeding sites in central Minnesota equipped with GPS-GSM transmitters. Overall, juvenile cranes left wintering areas later than adults and took longer to reach the breeding grounds following their first spring migration. Adults flew directly to previous breeding areas and established defended territories, whereas juvenile cranes exhibited low site fidelity and highly tortuous long-distance movements, primarily from April-June. We hypothesize that this behavior is due to prospecting for future potential breeding areas. Prospecting is well-documented among juveniles of long-lived avian species; however, we document for the first time the long-distance movements of non-breeding juvenile sandhill cranes by using high-resolution GPS telemetry data over a large geographic range.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:171

Key words: *Grus canadensis*, Minnesota, prospecting, sandhill crane, spring movements.

THE FIRST SIX YEARS OF THE LOUISIANA WHOOPING CRANE REINTRODUCTION

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Abstract: Beginning in March 2011, costume-reared juvenile whooping cranes (*Grus americana*) were released at the White Lake Wetlands Conservation Area (WLWCA) in southwestern Louisiana in an effort to re-establish a resident population. Six cohorts totaling 75 birds have been released through October 2016 with 25 additional birds slated to be released by the end of the year. In 2015, a second release pen was constructed at the Rockefeller Wildlife Refuge to allow for the release of multiple cohorts each year. Although 1-year survival has been 70-75% for the 2011-2014 cohorts, overall survival is 44% (33 birds survive of the 75 released). Gunshot is 1 of the leading causes of mortality; 10 mortalities are attributed to shootings. Released cranes continue to leave the WLWCA marsh and make seasonal movements; many utilize private property, primarily agricultural wetlands in rice and crawfish (*Procambarus* spp.) fields. Reproductive behavior was first documented in 2013 when 1 pair built 2 nest platforms. Eggs were first produced in spring 2014 when 1 pair produced 4 eggs in 2 nesting attempts. The number of nesting pairs grew in 2015 ($n = 4$) and 2016 ($n = 5$). Of 6 different breeding pairs, 4 have produced at least 1 fertile egg. Eleven of 16 nest attempts have been in actively farmed crawfish ponds with none abandoned due to the disturbance created by routine farming operations. Renesting rate of pairs with unsuccessful first nests has been high (67%). One pair successfully hatched 2 chicks and reared 1 to fledging in 2016.

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Key words: *Grus americana*, Louisiana, reintroduction, reproduction, Rockefeller Wildlife Refuge, White Lake Wetlands, whooping crane.

MILESTONE REACHED IN REINTRODUCED WHOOPING CRANE POPULATION: FIRST CHICKS HATCHED IN THE WILD IN LOUISIANA IN MORE THAN 75 YEARS

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Abstract: The whooping crane (*Grus americana*) reintroduction program in Louisiana, which began releasing captive-reared cranes in 2011, reached an important milestone in 2016 with the successful hatching of 2 chicks. This marked the first time in over 75 years that whooping crane chicks hatched in the wild in Louisiana. The successful hatches resulted from the nest of a newly formed pair consisting of a 4-year-old female and 3-year-old male. The pair was observed nest building on 11 March on a crawfish (*Procambarus* spp.) farm in Jefferson Davis Parish and the first egg was laid shortly thereafter. Biologists with the Louisiana Department of Wildlife and Fisheries monitored the nest throughout the incubation period to collect data on incubation behavior and monitor the progress of the nest. Observed incubation times over 6 3-hour monitoring periods were similar for the female ($\bar{x} = 78.8$ min) and male ($\bar{x} = 81.8$ min). The first chick hatched on 11 April followed by the second chick 2 days later. Both chicks were successfully reared for 1 month before the smaller of the 2 disappeared. The surviving chick was successfully reared to fledging and remains with its parents as of November 2016. So far, crane pairs have demonstrated an ability to incubate nests to full term on actively farmed crawfish ponds. This is encouraging because we anticipate more nests will be constructed in this environment as the timing of crawfish production in Louisiana coincides with the whooping crane breeding season and these shallowly-flooded ponds are well-suited to their nesting requirements.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:172

Key words: chick hatching, crawfish ponds, *Grus americana*, Louisiana, milestone, reintroduction program, whooping crane.
